US009051159B2

(12) **United States Patent**
Walker et al.

(10) **Patent No.: US 9,051,159 B2**
(45) **Date of Patent: Jun. 9, 2015**

(54) **COLUMN CONNECTOR SYSTEM**

(71) Applicant: **Manitowoc Crane Companies, LLC**, Manitowoc, WI (US)

(72) Inventors: **Robert J. Walker**, Manitowoc, WI (US); **David J. Pech**, Manitowoc, WI (US)

(73) Assignee: **Manitowoc Crane Companies, LLC**, Manitowoc, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/109,099**

(22) Filed: **Dec. 17, 2013**

(65) **Prior Publication Data**

US 2014/0174018 A1 Jun. 26, 2014

Related U.S. Application Data

(60) Provisional application No. 61/740,256, filed on Dec. 20, 2012.

(51) **Int. Cl.**
B66C 23/70 (2006.01)

(52) **U.S. Cl.**
CPC ***B66C 23/70*** (2013.01); *Y10T 403/553* (2015.01)

(58) **Field of Classification Search**
CPC B66C 23/82; B66C 23/70; Y10T 29/49; Y10T 29/49826; Y10T 29/49947; Y10T 29/4978; Y10T 403/18; Y10T 403/553; Y10T 403/7075
USPC 52/637, 650.1, 651.05, 848; 212/177, 212/299, 300, 347, 350; 403/294, 378, 364, 403/408.1, 300, 308
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,529,454 A 11/1950 Marcantonio
2,975,910 A * 3/1961 Conrad 212/300
(Continued)

FOREIGN PATENT DOCUMENTS

DE 3706301 C1 * 10/1987 ..... B66C 23/64
DE 4402005 A1 7/1995
(Continued)

OTHER PUBLICATIONS

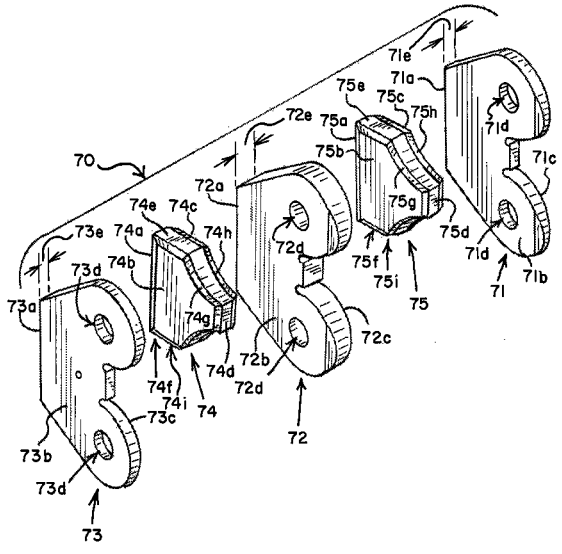
Liebherr LR13000 Welded Boom Connector (Feb. 14, 2011).
(Continued)

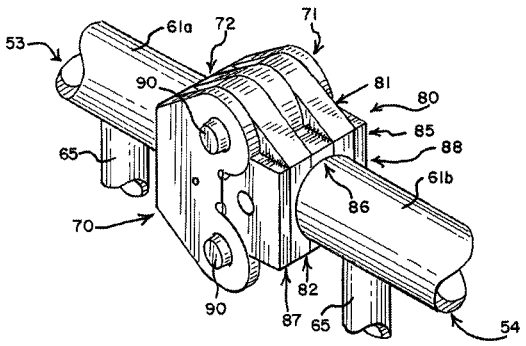
Primary Examiner — Brent W Herring
(74) *Attorney, Agent, or Firm* — Craig Buschmann; Brinks Gilson & Lione

(57) **ABSTRACT**

A connector for a column segment, such as a boom segment, of a crane includes n extensions, where n is a positive integer. Each extension has a first base and an aperture extends through the extension from a first side to a second side. The first connector also includes at least (n+y) plates, where y is selected from the group consisting of (−1, +1) such that the sum of (n+y) is a positive integer. The plate or plates are positioned in and coupled to the extensions in an alternating arrangement. Each plate includes a plate base aligned substantially in a plane with the first base of the extension to form a first connector mounting surface. A plurality of welds couple the plates to the extensions and the fabricated connector is then welded to the column segment. At least one extension is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to the first base.

20 Claims, 8 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

3,085,695	A	4/1963	Miller	
3,430,778	A	3/1969	Brown	
3,955,684	A	5/1976	Novotny	
3,977,530	A	8/1976	Helm et al.	
4,081,081	A	3/1978	Morrow, Sr. et al.	
4,273,244	A	6/1981	Jensen et al.	
4,582,205	A	4/1986	Berger et al.	
5,082,128	A *	1/1992	Franzen et al.	212/347
5,199,586	A	4/1993	Pech et al.	
5,443,169	A	8/1995	Pagel et al.	
5,484,069	A	1/1996	Lanning	
6,062,405	A	5/2000	Pech et al.	
6,089,388	A	7/2000	Willim	
6,131,751	A	10/2000	Pech et al.	
6,213,318	B1	4/2001	Walker	
6,481,202	B1	11/2002	Zuehlke et al.	
6,588,521	B1	7/2003	Porubcansky et al.	
6,702,132	B1	3/2004	Moore et al.	
7,007,764	B2	3/2006	Smith et al.	
7,270,243	B2	9/2007	Diehl	
7,503,623	B2 *	3/2009	Favaretto	296/203.01
7,546,928	B2	6/2009	Pech et al.	
7,565,982	B2	7/2009	Kurotsu et al.	
7,762,412	B2	7/2010	Porubcansky	
7,954,657	B2	6/2011	Holly et al.	
7,967,158	B2	6/2011	Pech et al.	
8,534,474	B2	9/2013	Holly et al.	
8,622,228	B2	1/2014	Mentink et al.	
8,739,988	B2 *	6/2014	Walker	212/177
2002/0053551	A1	5/2002	Koster et al.	
2006/0065616	A1	3/2006	Diehl	
2007/0256999	A1	11/2007	Kurotsu et al.	
2008/0099421	A1	5/2008	Pech et al.	
2008/0173605	A1	7/2008	Willim	
2008/0203045	A1	8/2008	Pech et al.	
2008/0264887	A1	10/2008	Porubcansky	
2010/0260539	A1 *	10/2010	Sakamoto et al.	403/294
2010/0326004	A1	12/2010	Daas et al.	
2011/0233165	A1	9/2011	Holly et al.	
2011/0284490	A1	11/2011	Liu et al.	
2012/0067840	A1	3/2012	Walker	
2012/0175333	A1 *	7/2012	Pech et al.	212/177
2013/0270208	A1 *	10/2013	Walker et al.	212/177

FOREIGN PATENT DOCUMENTS

EP	0376417	A1	7/1990
EP	0533323	A1	3/1993
EP	1205421	A1	5/2002
EP	1468955	A1	10/2004
EP	2431322	A1	3/2012
FR	2519620	A1	7/1983
JP	1988-212692	A	5/1988
JP	1990-225294	A	7/1990
JP	09156882		6/1997
JP	2004-189496	A	8/2004
NL	1035078	C1	3/2008
SU	1801180	A3	3/1993

OTHER PUBLICATIONS

Mammoet Connector PTC120DS Boom Photos2 (May 18, 2011).

EP Search Report, dated Mar. 12, 2014, for EP 13197111.1 (related application).

Brochure, "HC-238, 125-Ton Truck Crane" 3 pages (undated but prior to Nov. 29, 2007).

Brochure for Manitowoc 4100 Crane, 1 page (undated but prior to Sep. 16, 2009).

European Search Report for related European Application No. 14184310.2, dated Nov. 27, 2014 (5 pages).

Liebherr LR11350—four photographs of load, boom and mast hoist drum mounting (undated but prior to Sep. 16, 2009).

Manitowoc 16000—three photographs of load and mast hoist drums (undated but prior to Sep. 16, 2009).

Pages from "LR1600/2 Crawler Crane—Technical Data," Liebherr, pp. 1-10 (undated but prior to Sep. 16, 2009).

* cited by examiner

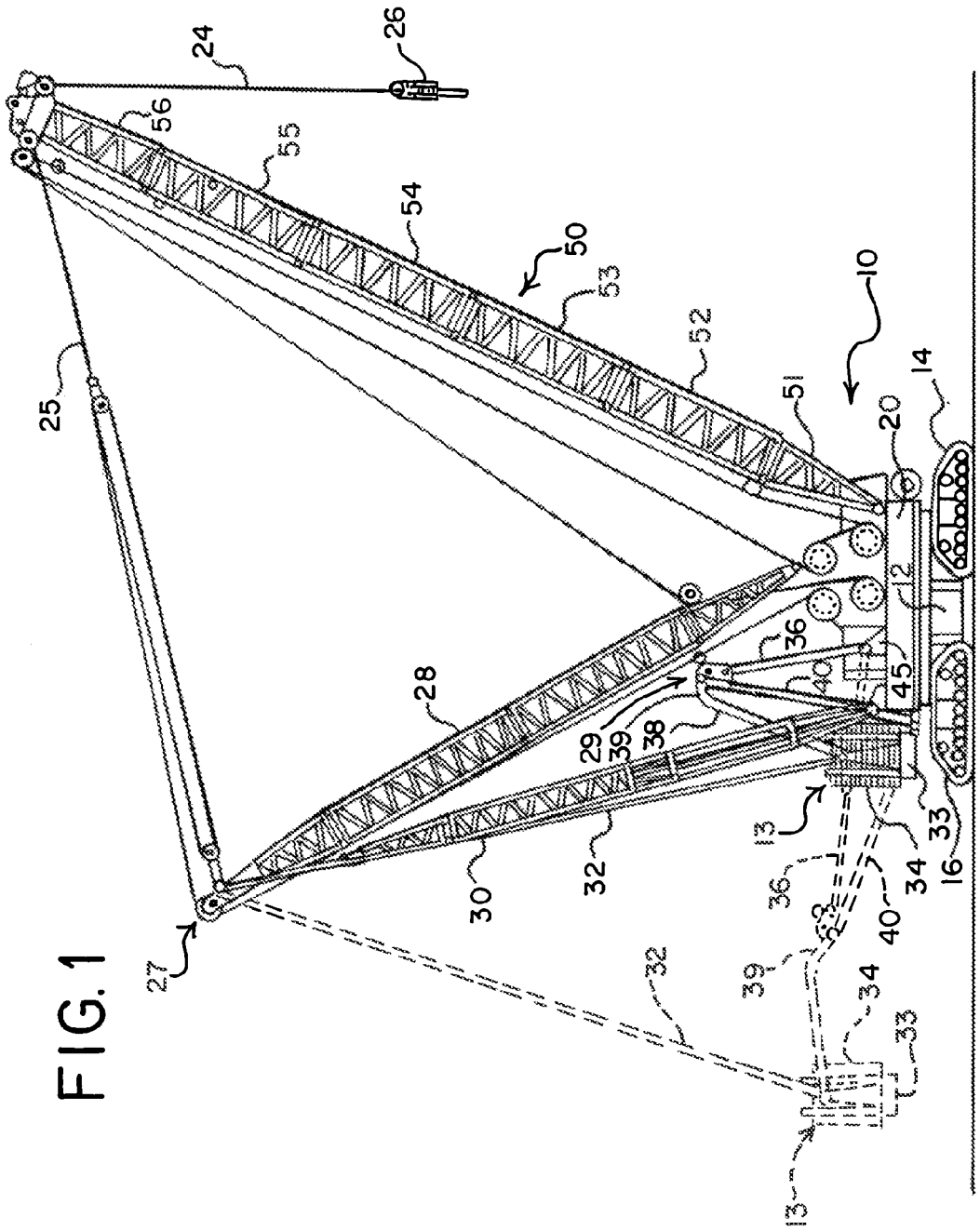

24
26
56
55
54
50
53
52
10
51
14
20
25
28
36
40
45
29
39
38
13
33
34
16
30
32
27
36
40
39
34
33
32
13

FIG. 1

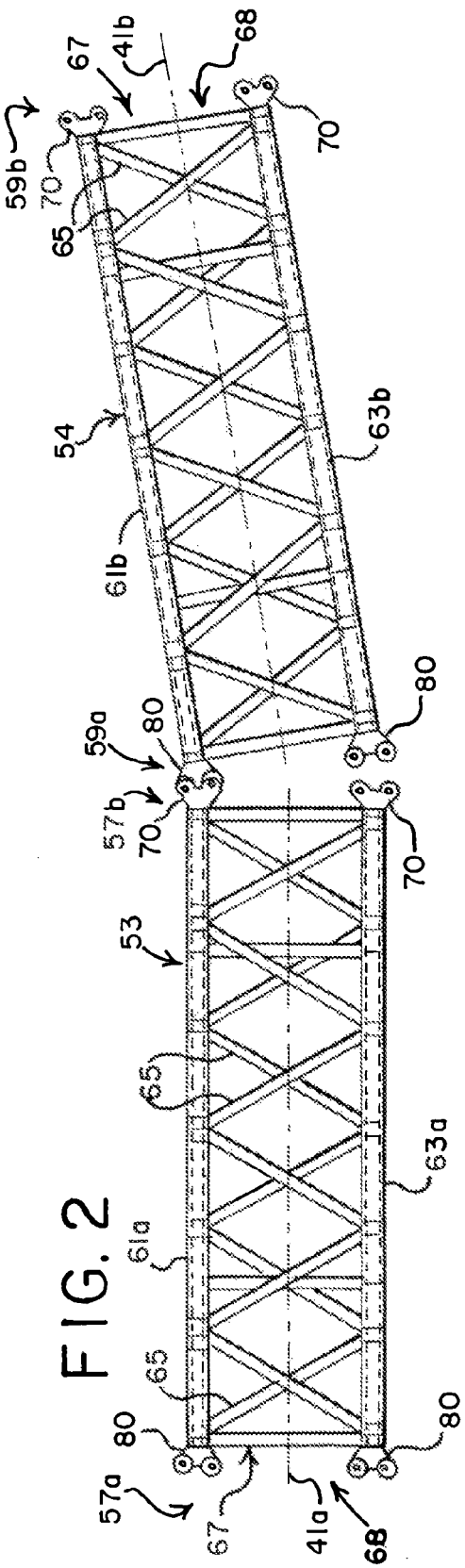

59b
67
41b
68
70
65
54
63b
61b
80
59a
57b
53
61a
63a
57a
41a

FIG. 2

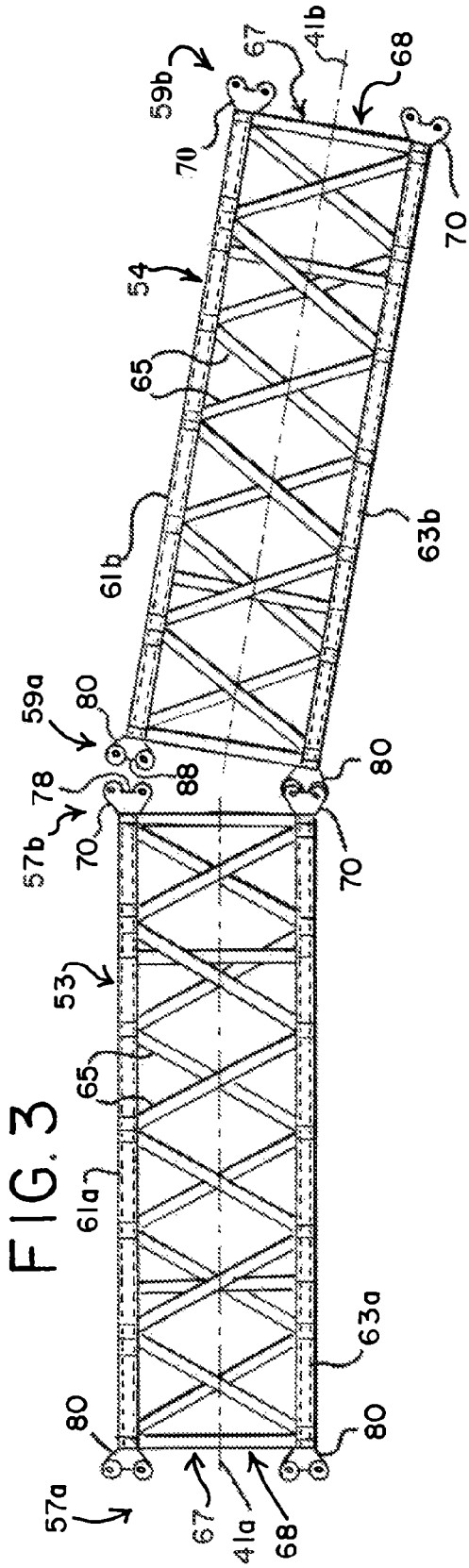

59b
67
41b
68
70
54
65
63b
61b
59a
80
78
88
57b
53
61a
63a
57a
41a

FIG. 3

FIG. 4a

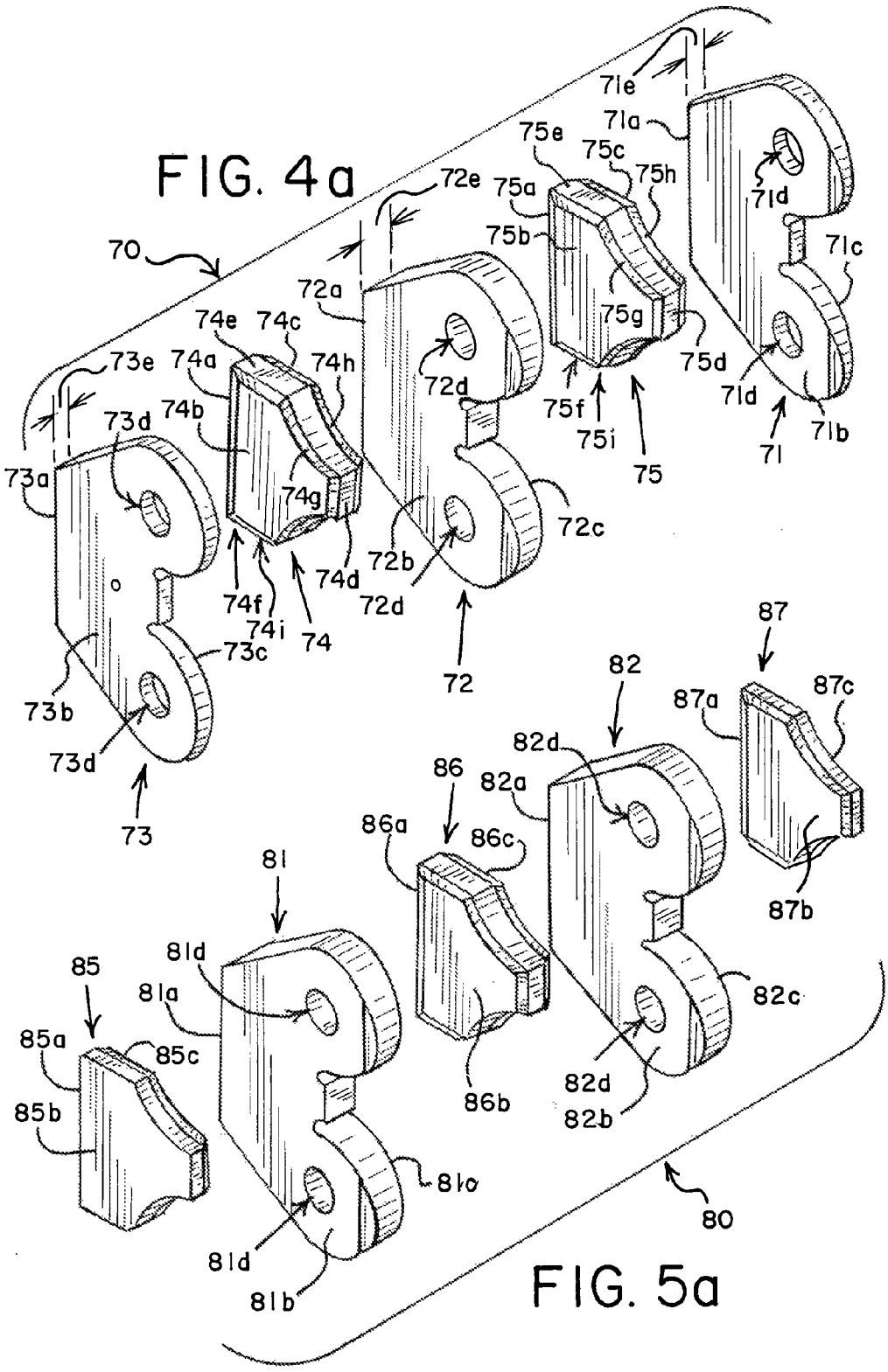

71e
71a
75e
75c
75h
71d
75a
72e
75b
71c
70
72a
74e
74c
75g
74a
73e
74h
72d
75d
75f
71d
73d
74b
75i
71b
75
71
73a
74g
72c
74f
74d
72b
74i
74
72d
87
73c
72
82
87a
87c
73b
82d
86
82a
73d
86a
86c
87b
73
81
82c
81d
85
81a
85a
85c
86b
82d
85b
82b
81c
80
81d
81b

FIG. 5a

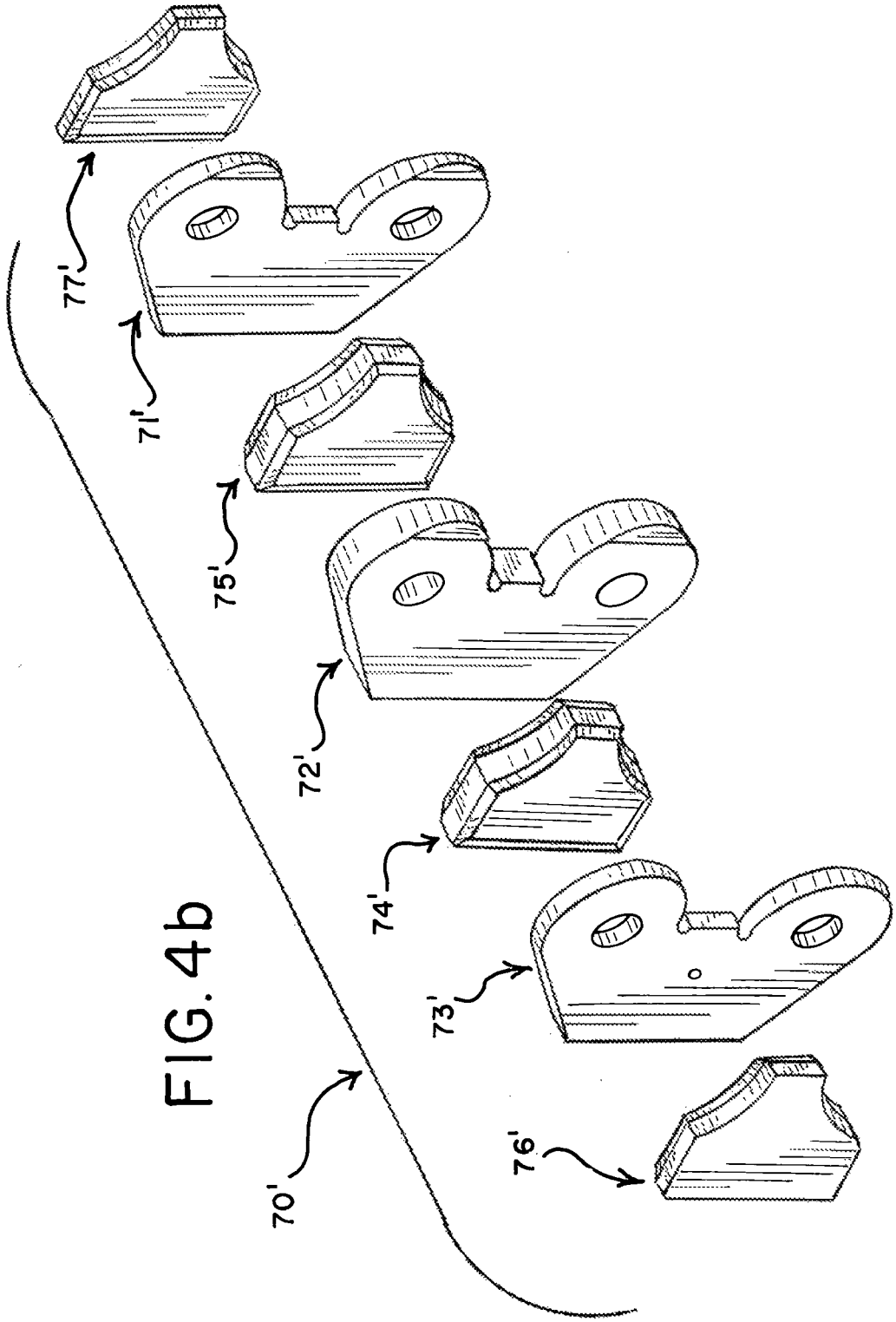


FIG. 4b

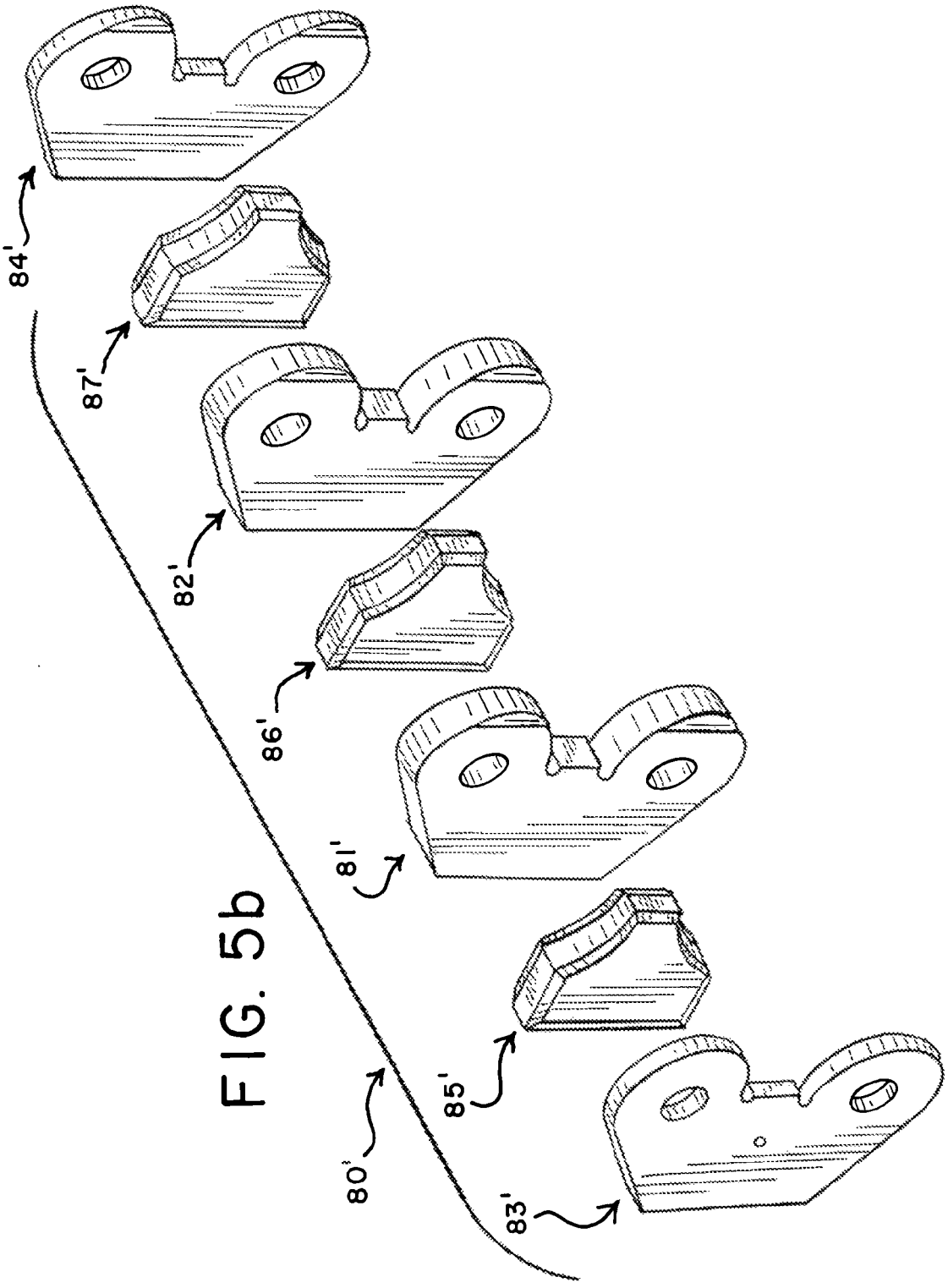


FIG. 5b

FIG. 6

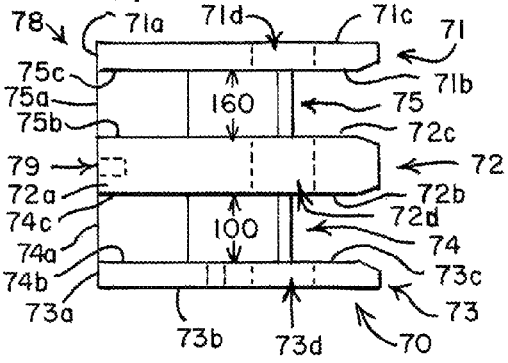


FIG. 8

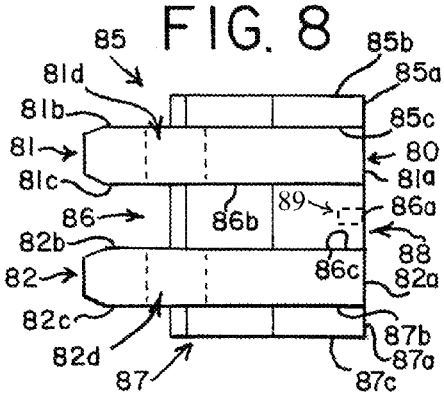


FIG. 7

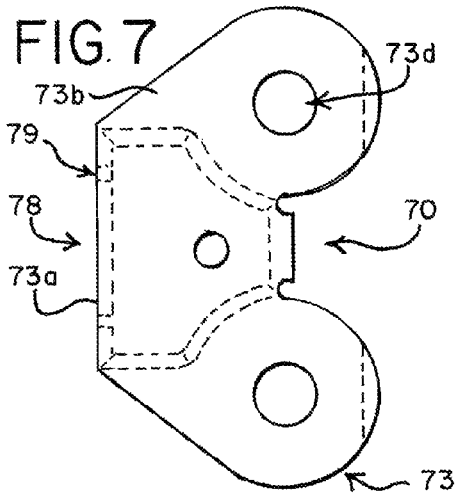
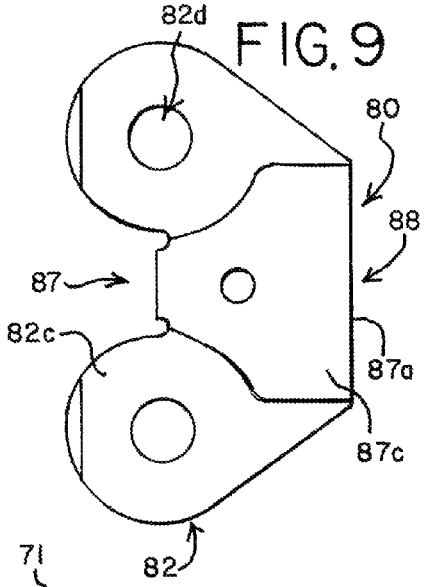


FIG. 9



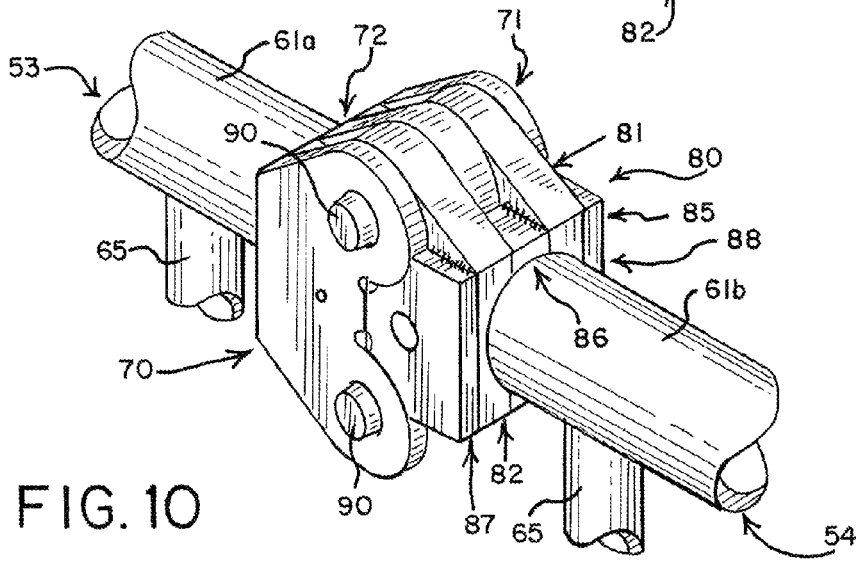


FIG. 10

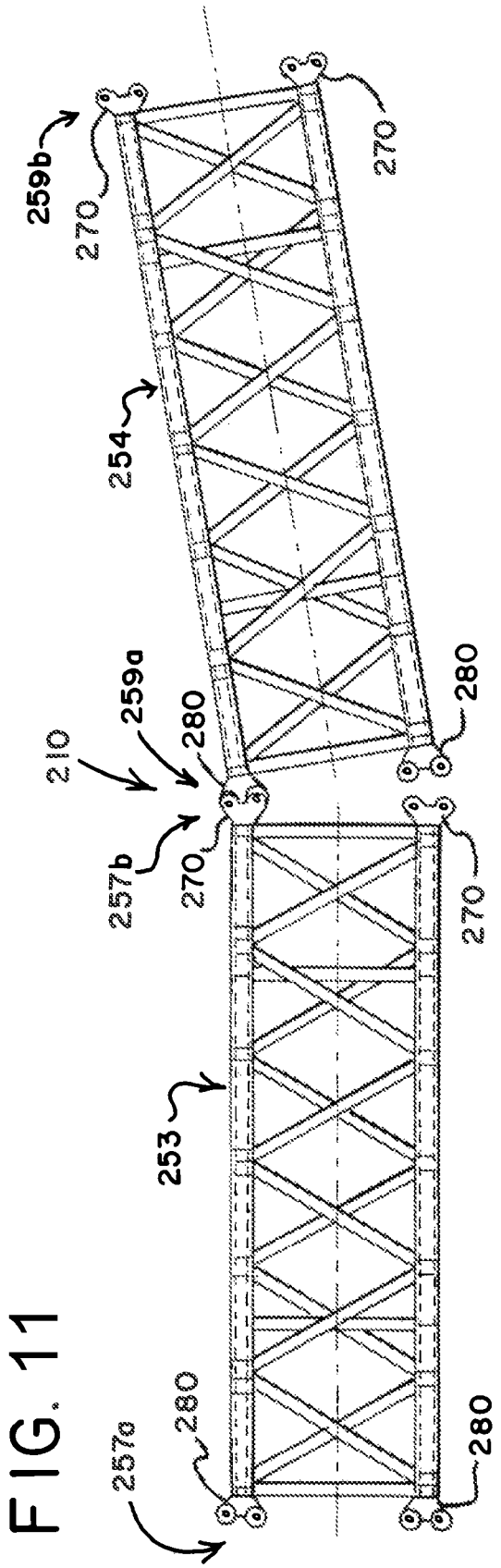


FIG. 11

FIG. 12

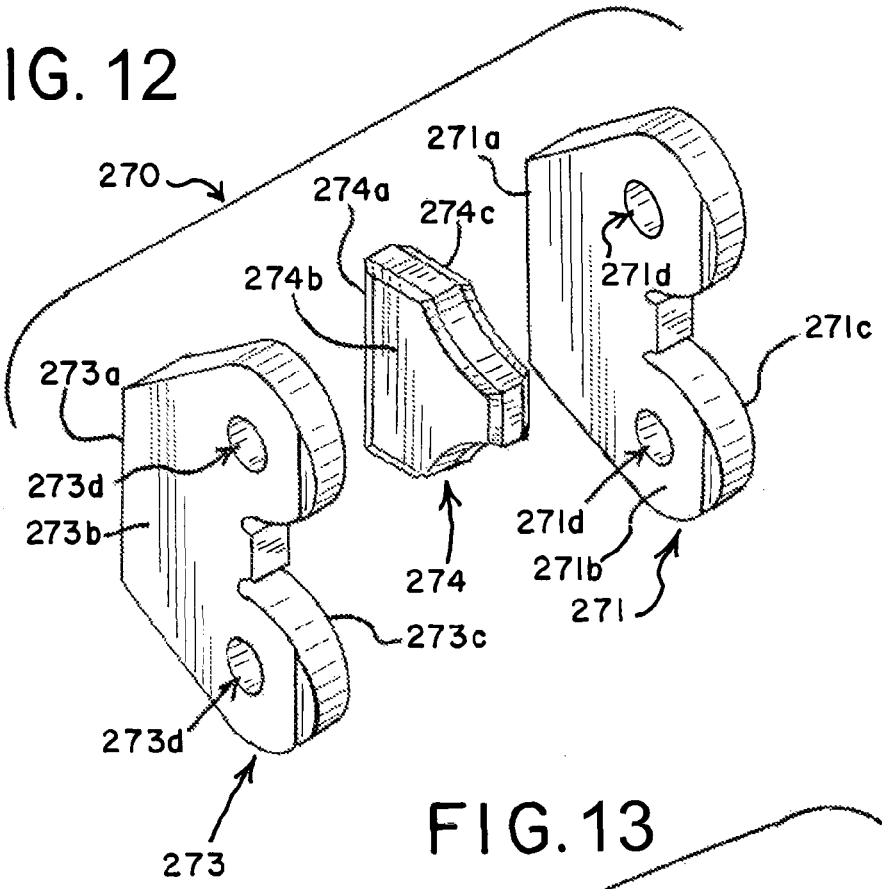
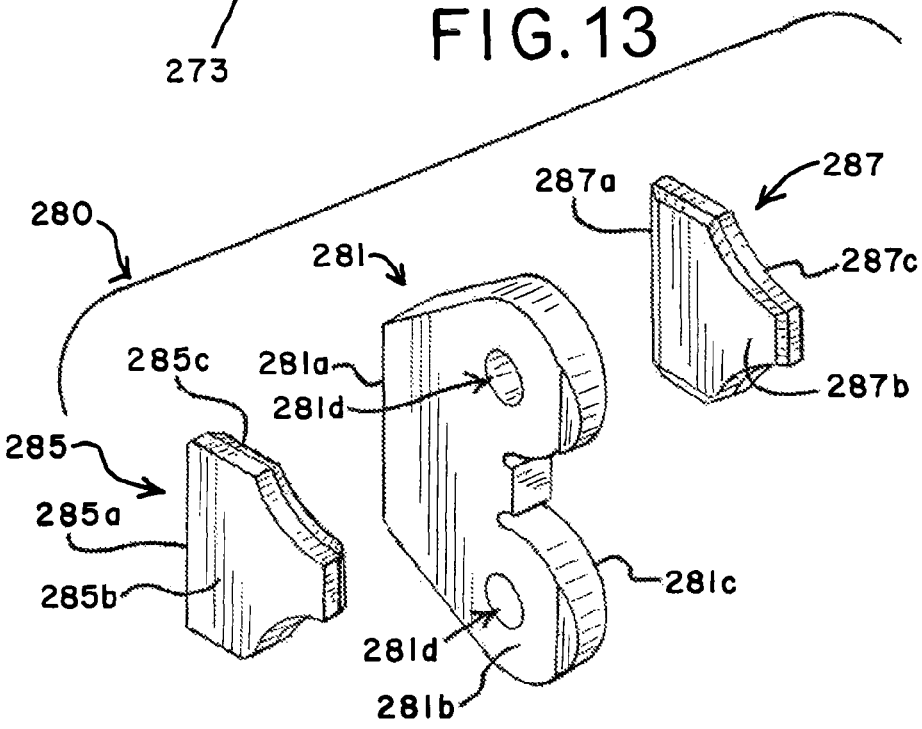

270
271a
274a
274c
274b
271d
271c
273a
273d
273b
274
271d
271b
271
273c
273d
273

FIG. 13


287
287a
280
281
287c
285c
281a
281d
287b
285
285a
285b
281c
281d
281b

COLUMN CONNECTOR SYSTEM

RELATED APPLICATION

The present patent document claims the benefit of priority to U.S. Provisional Patent Application No. 61/740,256, filed Dec. 20, 2012, and entitled "COLUMN CONNECTOR SYSTEM," the entire contents of each of which are incorporated herein by reference.

BACKGROUND

The present invention relates to lift cranes, and more particularly to connectors for coupling adjacent segments or sections of a column, such as a column used as a boom for cranes and the like.

Large capacity lift cranes typically have elongate load supporting column structures, commonly used for boom, mast, or jib, that comprise sectional column members secured in end-to-end abutting relationship. Predominantly, each of the column members is made of a plurality of chords and lacing or lattice elements. The terminal end portions of each chord are generally provided with connectors of one form or another to secure abutting column segments together and to carry compressive loads between abutting chords. Typical connectors comprise one or more extensions and plates secured by a pin carrying compressive loads in double shear.

An example 220 foot boom may be made of a 40 foot boom butt pivotally mounted to the crane upper works, a 30 foot boom top equipped with sheaves and rigging for lifting and supporting loads, with five sectional boom members in between: one 10 feet in length, one 20 feet in length and three 40 feet in length. Such an example boom has six boom segment connections. Typically each segment has four chords, and hence four connectors, making a total of 24 connectors that must be aligned and pinned to assemble the boom.

Typically, the loads carried by the boom members and, consequently, through the connectors require the lugs, also referred to as extensions, on the connector to be sufficiently thick to have sufficient strength to bear the loads. To carry very high loads for a high capacity crane, a typical single extension sandwiched between two plates, giving a double shear connection, requires a very large pin diameter to carry the compressive loads and, consequently, requiring the connectors to be very large. Standard specification plate steel often is insufficiently thick to form the extensions on a connector having sufficient strength to support the loads. For example, 100,000 pound per square inch (100 kpsi) plate steel is available in 4 inch thick plates and 130 kpsi plate steel is available in 2¾ inch thick plates, but neither is sufficiently thick in itself to form a connector capable of carrying the highest loads. While higher strength steel plates of greater thickness may be available, obtaining it typically requires a special order with a steel mill at commensurately higher costs and lead times. As a consequence, the connectors typically are formed of cast steel so as to have a sufficient thickness and strength.

Casting a connector, however, poses several challenges and inefficiencies. First, qualifying a foundry, preparing a mold, and casting a connector are a time intensive and, consequently, costly processes. Indeed, a long lead time and significant work may be invested in preparing a mold before the first connector can be cast. Provided a production run is sufficiently large it may make sense to mold many connectors, but only a small number of the largest cranes with the largest connectors in terms of both size and overall number may be manufactured.

Further, because of the long lead times and high costs of casting, the process is not easily adaptable to engineering and design changes, prototype testing, and the manufacture of one or a small number of components for use in destructive testing or as replacement parts. Stated differently, as a manufacturing process, the process of casting connectors often is not sufficiently agile and adaptable to rapidly changing business conditions and requirements.

Another disadvantage of cast connectors is that casting defects are not uncommon. As a consequence, a cast connector may require finish work or machining to ensure that a connector falls within the required specification and tolerances for a given application. This finish work often can be time consuming and expensive, too.

As a result, there exists a need for a connector that is quicker and easier to manufacture than a cast connector.

BRIEF SUMMARY

A column segment of a column of a crane includes a plurality of chords, each chord having a first end a second end. An embodiment of a connector is fabricated from two or more metal plates.

A first connector on the second end of at least one of the cords includes n extensions, where n is a positive integer, e.g., 1, 2, 3, and so on. Each extension has a first base and a first side extending away from the first base. A second side also extends away from the first base and is spaced apart from the first side. An aperture extends through the extension from the first side to the second side.

The first connector also includes at least (n+y) plates, where y is selected from the group consisting of (−1, +1) such that the sum of (n+y) is a positive integer. The plate or plates are positioned in and coupled to the extensions in an alternating arrangement. Each plate includes a plate base aligned substantially in a plane with the first base of the extension to form a first connector mounting surface. Each plate also includes a first plate side extending away from the plate base, the first plate side being positioned adjacent to one of the first side and the second side of one of the extensions. Each plate also includes a second plate side extending away from the plate base, the second plate side being spaced apart from the first plate side.

In some embodiments, a plurality of welds couples the plates to the extensions. Optionally, the fabricated connector is then welded to the column segment.

In some embodiments, the at least one extension is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to the first base.

In an embodiment of a column connector system, the connector system includes a first column segment having a first end and a second end and at least a second column segment also having a first end and a second end. A first connector on the second end of the first column segment includes at least two exterior extensions, each extension having a first base, a first side perpendicular to the first base, and a second side spaced apart from the first side and also perpendicular to the first base. A first aperture extends through each of the exterior extensions.

The first connector also includes at least one interior plate coupled to at least one of the exterior extensions. The interior plate includes an interior plate base aligned substantially in a plane with the first base to form a first connector mounting surface. A first interior plate side is perpendicular to the interior plate base and positioned adjacent to one of the first side and the second side of one of the exterior extensions. A

second interior plate side also is perpendicular to the interior plate base and is spaced apart from the first interior plate side.

The connector system also includes a second connector on the first end of the second column segment. The second connector includes at least one interior extension having a second base, a first side perpendicular to the second base, a second side also perpendicular to the second base and spaced apart from the first side, and a second aperture through the interior extension.

The second connector also includes a first exterior plate and a second exterior plate, at least one of the first exterior plate and the second exterior plate being coupled to the at least one interior extension. Each of the exterior plates has an exterior plate base aligned substantially in a plane with the second base of the at least one interior extension to form a second connecting mounting surface of the second connector. Each exterior plate also includes a first exterior plate side perpendicular to the exterior base plate and a second exterior plate side also perpendicular to the exterior base and spaced apart from the first exterior plate side.

A pin inserted through the first aperture of each exterior extension and the second aperture of each interior extension of the first and second connector couples the first connector to the second connector.

In some embodiments, the first connector includes a plurality of welds that couple the interior plate to the exterior extensions and the second connector includes a plurality of welds that couple the exterior plates to the interior extension. Optionally, at least one of the first connector and the second connector is then welded to one of the first column segment or the second column segment.

In an embodiment of a column or boom connector system, the connector system includes a first column segment having a first end and a second end and at least a second column segment also having a first end and a second end. A first connector on the second end of the first column segment includes two exterior extensions, each extension having a first base, a first side perpendicular to the first base, and a second side space apart from the first side and also perpendicular to the first base. A first aperture extends through each of the exterior extensions.

The first connector of the column connector system also includes at least one interior extension, the interior extension having a second base, a first side perpendicular to the second base, and a second side spaced apart from the first side and also perpendicular to the second base. A second aperture extends through the interior extension.

The first connector also includes an interior plate disposed between and coupled to the interior extension and one of the exterior extensions. Another interior plate is disposed between and coupled to the interior extension and the other exterior extension. Each of the interior plates includes an interior plate base aligned substantially in a plane with the first base and the second base to form a first connector mounting surface. A first interior plate side is perpendicular to the interior plate base and positioned adjacent to the second side of the exterior extension. A second interior plate side also is perpendicular to the interior plate base and is spaced apart from the first interior plate side. The second interior plate side is positioned adjacent to one of the first side and the second side of the interior extension.

The column connector system also includes a second connector on the first end of the second column segment. The second connector includes at least two interior extensions.

The second connector also includes at least one interior plate disposed between and coupled to each of the two interior extensions of the second connector. The interior plate base is aligned substantially in a plane with each of the first bases of the two interior extension of the second connector to form a second connector mounting surface. The first interior plate side is positioned adjacent to the second side of one of the interior extensions of the second connector, and the second interior plate side is positioned adjacent to the first side of the other interior extension of the second connector.

The second connector of the column connector system also includes an exterior plate coupled to one of the interior extensions of the second connector, and another exterior plate coupled to the other interior extension of the second connector. Each of the exterior plates include an exterior plate base aligned substantially in a plane with the second base of each of the interior extensions of the second connector to form a second connector mounting surface, a first exterior plate side perpendicular to the exterior plate base, and a second exterior plate side perpendicular to the exterior plate base. The second exterior plate side is also spaced apart from the first exterior plate side and positioned adjacent to one of the first side and the second side of one of the interior extensions of the second connector.

A pin inserted through the first aperture of each exterior extension and the second aperture of each interior extension of the first connector and the second connector couples the first connector to the second connector.

As used herein, "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C" and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

Various embodiments of the present inventions are set forth in the attached figures and in the Detailed Description as provided herein and as embodied by the claims. It should be understood, however, that this Summary does not contain all of the aspects and embodiments of the one or more present inventions, is not meant to be limiting or restrictive in any manner, and that the invention(s) as disclosed herein is/are and will be understood by those of ordinary skill in the art to encompass obvious improvements and modifications thereto.

Additional advantages of the present invention will become readily apparent from the following discussion, particularly when taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view of a crane with a sectional boom utilizing an embodiment of a boom connector system.

FIG. **2** is a side elevational view of two boom segments with boom or column connectors being brought together to form the boom on the crane of FIG. **1**.

FIG. **3** is a side elevational view of the two boom segments of FIG. **2** being brought together from a second position to form the boom on the crane of FIG. **1**.

FIG. **4***a* is an exploded perspective view of a first connector of a first embodiment of a column connector system.

FIG. **4***b* is an exploded perspective view of a first connector of a second embodiment of a column connector system.

FIG. **5***a* is an exploded perspective view of a second connector of the first embodiment of a column connector system.

FIG. **5***b* is an exploded perspective view of a second connector of the second embodiment of a column connector system.

FIG. **6** is a top plan view of the first connector of FIG. **4***a*.

FIG. **7** is a side elevation view of the first connector of FIG. **4***a*.

FIG. **8** is a top plan view of the second connector of FIG. **5***a*.

FIG. **9** is a side elevation view of the second connector of FIG. **5***a*.

FIG. **10** is a perspective view of the first connector of FIG. **4***a* coupled to the second connector of FIG. **5***a*.

FIG. **11** is a side elevation view of another embodiment of two boom segments with column connectors being brought together to form the boom on the crane of FIG. **1**.

FIG. **12** is an exploded perspective view of a first connector used in a third embodiment of a column connector system used in the column segment of FIG. **11**.

FIG. **13** is an exploded perspective view of a second connector used in the third embodiment of a column connector system used in the column segment of FIG. **11**.

DETAILED DESCRIPTION

The present invention will now be further described. In the following passages, different aspects of the invention are defined in more detail. Each aspect so defined may be combined with any other aspect or aspects unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

For ease of reference, designation of "top," "bottom," "horizontal" and "vertical" are used herein and in the claims to refer to portions of a sectional column or sectional boom in a position in which it would typically be assembled on or near the surface of the ground. These designations still apply although the boom may be raised to different angles, including a vertical position.

The mobile lift crane **10**, as shown in FIG. **1**, includes lower works, also referred to as a carbody **12**, and moveable ground engaging members in the form of crawlers **14** and **16**. (There are of course two front crawlers **14** and two rear crawlers **16**, only one each of which can be seen from the side view of FIG. **1**.) In the crane **10**, the ground engaging members could be just one set of crawlers, one crawler on each side. Of course additional crawlers than those shown, or other ground engaging members such as tires, can be used.

A rotating bed **20** is rotatably connected to the carbody **12** using a roller path, such that the rotating bed **20** can swing about an axis with respect to the ground engaging members **14**, **16**. The rotating bed supports a boom **50** pivotally mounted on a front portion of the rotating bed; a mast **28** mounted at its first end on the rotating bed; a backhitch **30** connected between the mast and a rear portion of the rotating bed; and a moveable counterweight unit **13** having counterweights **34** on a support member **33**. The counterweights may be in the form of multiple stacks of individual counterweight members on the support member **33**.

Boom hoist rigging **25** between the top of mast **28** and boom **50** is used to control the boom angle and transfers load so that the counterweight **34** can be used to balance a load lifted by the crane. A hoist line **24** extends from the boom **50**, supporting a hook **26**. The rotating bed **20** may also includes other elements commonly found on a mobile lift crane, such as an operator's cab and hoist drums for the rigging **25** and hoist line **24**. If desired, the boom **50** may comprise a luffing jib pivotally mounted to the top of the main boom, or other boom configurations. The backhitch **30** is connected adjacent the top of the mast **28**. The backhitch **30** may comprise a lattice member designed to carry both compression and tension loads as shown in FIG. **1**. In the crane **10**, the mast **28** is held at a fixed angle with respect to the rotating bed during crane operations, such as a pick, move and set operation.

The counterweight unit **13** is moveable with respect to the rest of the rotating bed **20**. In the embodiment of the crane **10** depicted, the counterweight unit **13** is designed to be moved in and out with respect to the front of the crane **10** in accordance with the invention disclosed in U.S. Pat. Nos. 7,546,928 and 7,967,158, each entitled "Mobile Lift Crane With Variable Position Counterweight." A tension member **32** connected adjacent the top of the mast **28** supports the counterweight unit **13**. A counterweight movement structure **29** is connected between the rotating bed **20** and the counterweight unit **13** such that the counterweight unit **13** may be moved to and held at a first position in front of or forward of a top **27** of the mast **28**, as shown in solid lines in FIG. **1**, and moved to and held at a second position rearward of the top **27** of the mast **28**, as shown in dotted lines in FIG. **1**.

In the crane **10**, the counterweight movement structure **29** includes a hydraulic cylinder **36**, pivot frame **40** and a rear arm **38** may be used to move the counterweight unit **13**. (As with the crawlers **14** and **16**, the rear arm **38** actually has both left and right members, only one of which can be seen in FIG. **1**, the pivot frame **40** has two side members, and the hydraulic cylinder **36** comprises two cylinders that move in tandem. Alternatively, one larger hydraulic cylinder, or a rack and pinion structure, powered by preferably four hydraulic motors, could be used in place of the two hydraulic cylinders **36** to provide the linear actuation. Further, the pivot frame **40** could be made as a solid plate structure, and the two rear arms **38** could be replaced by one single structure.) The pivot frame **40** is connected between the rotating bed **20** and hydraulic cylinder **36**, and the rear arm **38** is connected between the pivot frame **40** and the counterweight unit **13**. The hydraulic cylinder **36** is pivotally connected to the rotating bed **20** on a support frame **45** which elevates the hydraulic cylinder **36** to a point so that the geometry of the cylinder **36**, pivot frame **40** and rear arm **38** can move the counterweight unit **13** through its entire range of motion. In this manner the cylinder **36** causes the rear arm **38** to move the counterweight unit **13** when the cylinder **36** is retracted and extended.

Rear arms **38** have an angled portion **39** at an end that connects to the pivot frame **40**. This allows the rear arms **38** to connect directly with the side members of pivot frame **40**. The angled portion **39** prevents the rear arms **38** from interfering with the side members of the pivot frame **40** the when the counterweight unit **13** is in the position shown in solid lines in FIG. **1**.

The boom **50** is made of several sectional members, typically referred to as boom segments or column segments. The sectional members illustrated in FIG. **1** include a boom butt **51**, boom or column insert segments **52**, **53**, **54**, and **55**, which may vary in number and be of different lengths, and a boom top **56**. The boom butt **51**, boom or column insert segments **52**, **53**, **54**, and **55**, and the boom top **56** typically are comprised of multiple chords **61***a*, **61***b*, **63***a*, **63***b* (FIG. **2**).

As illustrated in FIGS. **2** and **3**, each boom or column segment **53** and **54** has a rectangular cross section with a chord **61***a*, **63***a* and **61***b*, **63***b*, respectively, on each boom or column segment **53**, **54**. The boom segments **53** and **54**, which are representative and may be considered as a first boom or column segment and a second boom or column segment, respectively, each have a longitudinal axis **41***a* and **41***b* (FIG. **2**). The first boom segment **53** includes a first end **57***a* and a second end **57***b*. Likewise, the second boom segment **54** includes a first end **59***a* and a second end **59***b*. The second end **57***b* of the first boom segment **53** is coupled to the first end **59***a*

of the second boom segment **54**. There are two top chords **61***a*, **61***b* and two bottom chords **63***a*, **63***b* (only one of each of which can be seen in the side views) interconnected by intermediate lacing or lattice elements **65** connecting the chord **61***a* to chord **63***a* and chord **61***b* to chord **63***b* into a fixed, parallel relationship forming each respective boom segment **53** and **54**. In the embodiment shown, the chord members **61***a*, **61***b* and **63***a*, **63***b* are made of steel with a circular, tubular cross section, although it is understood that the chord members can be formed to have a different cross-section, including oval, rectangular, angled or L-shaped, and others.

Each chord member **61***a*, **61***b*, **63***a*, **63***b* has a vertical neutral axis and a horizontal neutral axis. Compressive loads applied at the intersection of the vertical and horizontal neutral axes of a chord **61***a*, **61***b*, **63***a*, **63***b*, or symmetrically about the horizontal and vertical neutral axes, will not induce bending moments within the chord **61***a*, **61***b*, **63***a*, and **63***b*. Thus it is preferable that a connector **70**, **80** used to connect boom segments **53**, **54**, respectively, together be mounted on the boom segments **53**, **54** at the ends of the chords **61***a*, **61***b*, **63***a*, and **63***b* in such a way that compressive loads transmitted through the connectors **70**, **80** are symmetrical about the neutral axes of the chords **61***a*, **61***b*, **63***a*, and **63***b*.

Thus, it can be seen that a column segment or boom segment **53** includes a plurality of chords **61***a*, **63***a* in which a lattice structure **65** couples each chord **61***a* to at least another chord **63***a*, each chord **61***a*, **63***a* having a first end **57***a* and a second end **57***b*. A first connector **70** is affixed to the second end **57***b* of a top chord **61***a* and a bottom chord **63***a* on the first column or boom segment **53**. Similarly, column segment or boom segment **54** includes another plurality of chords **61***b*, **63***b* in which another lattice structure **65** couples each chord **61***b* of the another plurality of chords **61***b*, **63***b* to at least another chord **63***b*, each chord **61***b*, **63***b* having a first end **59***a* and a second end **59***b*. The second connector **80** is affixed to the first end **59***a* of a top chord **61***b* and a bottom chord **63***b* on the second column or boom segment **54**. As explained below, embodiments of the first connector **70** couple with the second connector **80** to mate the first boom or column segment **53** to the second boom or column segment **54**.

As shown in FIG. **2**, either the connectors **70**, **80** on the top chords **61***a*, **61***b* can be connected first, or, as shown in FIG. **3**, the connectors **70**, **80** on the bottom chords **63***a*, **63***b* can be connected first, while the boom segments are in a non-aligned configuration. The boom segments can then be pivoted and will automatically stop in a position where the additional connectors are aligned. It is also possible that the boom segments can be brought together with the longitudinal axes of the segments already lined up.

While the discussion generally refers to the boom **50** and its boom or column segments and how they are coupled with embodiments of the first connector **70** and the second connector **80**, it is noted that these connectors may also connect the various boom and/or column segments in the mast **28**, the backhitch **30**, and elsewhere that boom or column segments are to be coupled together.

FIGS. **4***a*, **5***a* and **6-10** illustrate embodiments of the first connector **70** and a second connector **80**. As best seen in the exploded view of FIG. **4***a*, top view of FIG. **6**, and side view of FIG. **7**, the first connector **70** includes n extensions **71**, **72**, **73**, where n is a positive integer, e.g., 1, 2, 3, and so on. Consequently, n, in this illustrated embodiment, is the positive integer 3. Each extension **71**, **72**, **73** has a first base **71***a*, **72***a*, and **73***a*, as best seen in the top view in FIG. **6**.

Each extension **71**, **72**, **73** also includes a first side **71***b*, **72***b*, **73***b* extending away from the first base **71***a*, **72***a*, **73***a* and a second side **71***c*, **72***c*, **73***c*, also extending away from the first base **71***a*, **72***a*, **73***a* and spaced apart from each respective first side **71***b*, **72***b*, **73***b*. It is understood that while specific reference is made to a first side (e.g., **71***b*, **72***b*, **73***b*) and a second side (e.g., **71***c*, **72***c*, **73***c*), one of skill in the art would understand that the references to the first side and the second side are interchangeable. That is, what is referred to as the first side could just as easily be referred to as the second side and vice-versa. Thus, while throughout this application references to the various embodiments in the specification and the figures will be to a specific side, such as a first side and second side, it is understood that the formulation could be reversed.

Optionally, at least one of the first side **71***b*, **72***b*, **73***b* and the second side **71***c*, **72***c*, **73***c* of the extensions **71**, **72**, **73** is perpendicular to its respective first base **71***a*, **72***a*, and **73***a*. In the event n is an odd integer greater than or equal to 1, the connector **70** includes one or more interior extensions. In the embodiment illustrated in FIG. **4***a*, the extension **72** is an interior extension and includes a first distance **72***e* between the first side **72***b* and the second side **72***c*. Likewise, in the event that n is an integer greater than or equal to 2, the connector optionally includes at least two exterior extensions, such as extensions **71** and **73**, each having a second distance **71***e*, **73***e* between the first side **71***b*, **73***b* and the second side **71***c*, **73***c*, that is less than the first distance **72***e*. Thus, as can be seen in the embodiment illustrated in FIGS. **4***a* and **6**, because n equals 3, the connector **70** includes the interior extension **72** and two exterior extensions **71**, **73**.

Each extension **71**, **72**, **73** also includes at least one first aperture **71***d*, **72***d*, **73***d*—two apertures are illustrated in each extension in the figures—that extends through each extension **71**, **72**, **73** from the first side **71***b*, **72***b*, **73***b* to the second side **71***c*, **72***c*, **73***c*.

Preferably the extensions **71**, **72**, **73** are formed of metal. Typically, the metal is of any known type of steel, but other metals may be selected to form the extensions. In some embodiments, at least one extension **71**, **72**, **73** is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to the first base **71***a*, **72***a*, **73***a*.

The first connector **70** also includes at least (n+y) plates **74**, **75** where y is selected from the group consisting of (−1, +1) such that the sum of (n+y) is a positive integer. As previously noted, because n equals 3 in FIG. **4***a* and two plates **74**, **75** are illustrated, y consequently must be −1 (3 extensions−1=2 plates). Alternatively, and as illustrated in FIG. **4***b*, in the event y is +1 the connector **70'** would appear with the same elements noted with a prime notation. Thus, this embodiment in FIG. **4***b* includes three extensions, **71'**, **72'**, **73'**, and four plates **74'**, **75'**, **76'**, and **77'** (3 extensions+1=4 plates). Reference will generally be made to the embodiment disclosed in FIG. **4***a*, but each of the elements and features identified in FIG. **4***a* are present in the embodiment in FIG. **4***b*.

The plates **74**, **75** are positioned in and coupled to the extensions **71**, **72**, **73** in an alternating arrangement as seen in FIGS. **4***a* and **6**. Each plate **74**, **75** includes a plate base **74***a*, **75***a* substantially aligned in a plane with the first base **71***a*, **72***a*, **73***a* of the extensions **71**, **72**, **73** to form a first connector mounting surface **78** (FIGS. **6** and **7**). Aligned, or substantially aligned in a plane refers to the engineering tolerances to which the first connector mounting surface **78**, and others, are formed and assembled. Each plate **74**, **75** also includes a first plate side **74***b*, **75***b*, extending away from the plate base **74***a*, **75***a*, the first plate side **74***b*, **75***b* being positioned adjacent to one of the first side **71***b*, **72***b*, **73***b* and the second side **71***c*, **72***c*, **73***c* of at least one of the extensions **71**, **72**, **73**. Thus, as illustrated, the first plate side **74***b* of plate **74** is adjacent to the second side **73***c* of the extension **73**. Similarly, the first plate

side **75***b* of plate **75** is positioned adjacent second side **72***c*. Each plate **74**, **75** also includes a second plate side **74***c*, **75***c* extending away from the plate base **74***a*, **75***a*, the second plate side **74***c*, **75***c* being spaced apart from the first plate side **74***b*, **75***b*.

Optionally, one or more of the plates **74**, **75** includes a plate surface **74***d*, **75***d* spaced laterally apart from the plate base **74***a*, **75***a*, respectively, a plate top **74***e*, **75***e* extending away from the plate base **74***a*, **75***a* that intersects the first plate side **74***b*, **75***b* and the second plate side **74***c*, **75***c*. In addition, the plates **74**, **75** optionally include a plate bottom **74***f*, **75***f* spaced apart from the plate top **74***e*, **75***e*, while also extending away from the plate base **74***a*, **75***a* and intersecting the first plate side **74***b*, **75***b* and the second plate side **74***c*, **75***c*. Embodiments of such a plate **74**, **75** include, but are not limited to, plates having the shape of a square, rectangle, parallelogram, trapezoid, and other such shapes.

Optionally, the plates **74**, **75** further include a first surface **74***g*, **75***g* that extends away from the plate base **74***a*, **75***a*, the plate surface **74***d*, **75***d*, the plate top **74***e*, **75***e*, and the plate bottom **74***f*, **75***f* until the first surface **74***f*, **75***f* meets the first plate side **74***b*, **75***b*. In addition, or alternatively, the plates **74**, **75** further include a second surface **74***h*, **75***h* that extends away from the plate base **74***a*, **75***a*, the plate surface **74***d*, **75***d*, the plate top **74***e*, **75***e*, and the plate bottom **74***f*, **75***f* until the second surface **74***h*, **75***h* meets the second plate side **74***c*, **75***c*. The first surface **74***g*, **75***g* and the second surface **74***h*, **75***h* can be, for example, a recess, a groove, such as a stress relief groove, chamfer, fillet, and other similar shapes. A purpose of the first surface **74***g*, **75***g* and the second surface **74***h*, **75***h* is that the surface provides additional space to permit a weld of adequate thickness and strength to be positioned between the plates **74**, **75** and the extensions **71**, **72**, and **73** as discussed below.

In some embodiments, the plates **74**, **75** are coupled or joined to the extensions **71**, **72**, **73** with welds **100** as illustrated in FIG. **6**. Welds **100** are located at least partly along a periphery or perimeter **74***i*, **75***i* of each plate **74**, **75** and, more preferably, the welds **100** are located around substantially the entire periphery or perimeter **74***i*, **75***i* of each plate **74**, **75**. The welds **100** may be formed by any welding process known in the art, including TIG welding, MIG welding, laser welding, and other known welding processes. The welds **100** may be formed as a continuous weld or they may be multiple welds formed in one or more welding steps.

The first connector mounting surface **78** is coupled or joined to the first column segment **53**, typically at an end of the chord **61***a*, **63***a*. The first connector mounting surface **78** can be joined to the first column segment **53** in any manner known in the art, including welding, bolting, and other methods. To assist in coupling the first connector mounting surface **78** to the first column segment **53**, the first column connecting surface optionally includes at least one hole or recess **79**, illustrated in FIG. **6**, configured to align the first connector **70** to the first column segment **53**. While the hole **79** is illustrated in the first base **72***a* of the extension **72**, it optionally can be located elsewhere on the first connector mounting surface **78** (e.g., on any of the first base **71***a*, **72***a*, **73***a* and the plate base **74***a*, **75***a*).

As previously noted and illustrated in FIGS. **2** and **3**, the connector **70** couples with a connector **80** so as to join the column segment **53** with the column segment **54**. As best seen in the exploded view of FIG. **5***a*, top view of FIG. **8**, and side view of FIG. **9**, the second connector **80** includes (n+y) extensions **81** and **82** similar to the extensions **71**, **72**, **73** and with (n+y) defined above. As previously noted, because n equals 3 and y is −1, consequently and as illustrated in FIGS. **5***a* and **8** there must be two (2) extensions **81**, **82**. Alternatively, and in the embodiment illustrated in FIG. **5***b*, in the event y is +1 the connector **80'** would appear with the same elements noted with a prime notation. Consequently, (n+y) would be the positive integer 4 and the embodiment in FIG. **5***b* includes four (4) extensions, **81'**, **82'**, **83'**, and **84'**. Reference will generally be made to the embodiment disclosed in FIG. **5***a*, but each of the elements and features identified in FIG. **5***a* are present in the embodiment in FIG. **5***b*.

Turning back to FIG. **5***a*, each extension **81**, **82** includes a second base **81***a*, **82***a*, as best seen in the top view in FIG. **8**. Each extension **81**, **82** also includes a first side **81***b*, **82***b* extending away from the second base **81***a*, **82***a* and a second side **81***c*, **82***c* also extending away from the second base **81***a*, **82***a* and spaced apart from each respective first side **81***b*, **82***b*.

Each extension **81**, **82** also includes at least one second aperture **81***d*, **82***d*—two apertures are illustrated in the extensions in the figures—that extends through each extension **81**, **22** from the first side **81***b*, **82***b* to the second side **81***c*, **82***c*.

The second connector **80** also includes at least n plates **85**, **86**, **87** (and **85'**, **86'**, **87'** in FIG. **5***b*). The plates **85**, **86**, **87** are positioned in and coupled to the extensions **81**, **82** in an alternating arrangement as seen in FIGS. **5***a* and **8**. Each plate **85**, **86**, **87** includes a plate base **85***a*, **86***a*, **87***a* substantially aligned in a plane with the second base **81***a*, **82***a* of the extensions **81**, **82** to form a second connector mounting surface **88**. Each plate **85**, **86**, **87** also includes a first plate side **85***b*, **86***b*, **87***b* extending away from the plate base **85***a*, **86***a*, **87***a*, the first plate side **85***b*, **86***b*, **87***b* being positioned adjacent to one of the first side **81***b*, **82***b* and the second side **81***c*, **82***c* of at least one of the extensions **81**, **82**. Thus, as illustrated, the first plate side **86***b* of plate **86** is adjacent to the second side **81***c* of the extension **81**. Similarly, the first plate side **87***b* of plate **87** is positioned adjacent to the second side **82***c* of extension **82**. Each plate **85**, **86**, **87** also includes a second plate side **85***c*, **86***c*, **87***c* extending away from the plate base **85***a*, **86***a*, **87***a*, the second plate side **85***c*, **86***c*, **87***c* being spaced apart from the first plate side **85***b*, **86***b*, **87***b*. Embodiments of such a plate **85**, **86**, **87** include, but are not limited to, plates having the shape of a square, rectangle, parallelogram, trapezoid, and other such shapes. Optionally, the second connector **80** can be cast as a unitary structure.

It is noted that in some embodiments the extensions **71**, **72**, **73** are substantially identical in shape and/or dimension to the extensions **81**, **82**, while in other embodiments the shape and the dimensions may differ. Likewise, in some embodiments the plates **74**, **75** are substantially identical in shape and/or dimension to the plates **85**, **86**, **87** while in other embodiments the shape and/or the dimensions may differ.

A pin **90**, as best seen in FIG. **10**, is inserted through the first aperture **71***d*, **72***d*, **73***d* of each extension **71**, **72**, **73** of the first connector **70** and the second aperture **81***d*, **82***d* of each extension **81**, **82** of the second connector **80**. The pin **90** couples the first connector **70** to the second connector **80** and, consequently, the first column or boom segment **53** to the second column or boom segment **54**.

An embodiment of a column or boom connector system **110**, indicated in FIGS. **2** and **3**, includes the first column or boom segment **53** having the first end **57***a* and the second end **57***b*. The boom connector system **110** also includes at least the second column or boom segment **54** having a first end **59***a* and a second end **59***b*.

As it relates to the boom or column connector system **110**, another manner in which to consider the first connector **70** and the second connector **80** are now described. Referring to FIGS. **4***a*, **6**, and **7**, a first connector **70** on the second end **57***b* of the first column or boom segment **53** includes at least two

extensions and, in the embodiment illustrated, three extensions **71**, **72**, and **73**. In the embodiment illustrated, the extensions **71** and **73** are exterior extensions and extension **72** is an interior extension. In this example, n equals 3.

An interior plate **74** is coupled to at least one exterior extension **71**, **73** (extension **73** in the embodiment illustrated) and the interior extension **72**. The first interior plate side **74***b* is positioned adjacent to the second side **73***c* of the exterior extension **73**. The second interior plate side **74***c* is positioned adjacent to the first side **72***b* of the interior extension **72**.

A second or another interior plate **75** is coupled to at least one exterior extension **71**, **73** (extension **71** in the embodiment illustrated) and the interior extension **72**. The another first interior plate side **75***b* is positioned adjacent to the second side **72***c* of the interior extension **72**. The another interior plate **75** also has another second interior plate side **75***c* perpendicular to the interior plate base **75***a*, which is spaced apart from the another first interior plate side **75***b*. The another second interior plate side **75***c* is positioned adjacent to the first side **71***b* of the exterior extension **71**.

The column or boom connector system **110** also includes a second connector **80** on the first end **59***a* of the second column or boom segment **54**, as seen in FIGS. **2** and **3**. The second connector **80** includes at least one interior extension **81** and, as illustrated in FIG. **5***a*, optionally includes at least another or a second interior extension **82**. The at least one interior extension **81** and at least another extension **82** each include a second base **81***a*, **82***a*, a first side **81***b*, **82***b* perpendicular to the second base **81***a*, **82***a*, and a second side **81***c*, **82***c* also perpendicular to the second base **81***a*, **82***a* and spaced apart from the first side **81***b*, **82***b*. A second aperture **81***d*, **82***d* extends through the interior extension **81**, **82** as illustrated in FIGS. **5***a*, **8**, and **9**.

As illustrated in FIG. **5***a*, a first exterior plate **85** is coupled to the at least one interior extension **81** and a second exterior plate **87** is coupled to the at least another interior extension/second interior extension **82**. Each of the first exterior plate **85** and the second exterior plate **87** has an exterior plate base **85***a*, **87***a* aligned substantially in a plane with the second base **81***a*, **82***a* of the at least one interior extension **81** to form a second connecting mounting surface **88** of the second connector **80**.

Each exterior plate **85**, **87** also includes a first exterior plate side **85***b*, **87***b* perpendicular to the exterior base plate **85***a*, **87***a* and a second exterior plate side **85***c*, **87***c* also perpendicular to the exterior base plate **85***a*, **87***a* and spaced apart from the first exterior plate side **85***b*, **87***b*. The second exterior plate side **85***c* of the first exterior plate **85** is positioned adjacent the first side **81***b* of the at least one interior extension **81** of the second connector **80**.

Optionally, one or more of the exterior plates **85**, **87** include an exterior plate surface **85***d*, **87***d* spaced laterally apart from the exterior plate base **85***a*, **87***a*. An exterior plate top **85***e*, **87***e* extends away from the exterior plate base **85***a*, **87***a* and intersects the first exterior plate side **85***b*, **87***b* and the second exterior plate side **85***c*, **87***c*. An exterior plate bottom **85***f*, **87***f* is spaced apart from the exterior plate top **85***e*, **87***e* and also extends away from the exterior plate base **85***a*, **87***a*. The exterior plate bottom **85***f*, **87***f* also intersects the first exterior plate side **85***b*, **87***b* and the second exterior plate side **85***c*, **87***c*. In some embodiments, a first surface **85***g*, **87***g* extends away from the exterior plate base **85***a*, **87***a*, the exterior plate surface **85***d*, **87***d*, the exterior plate top **85***e*, **87***e*, and the exterior plate bottom **85***f*, **87***f* until the first surface **85***g*, **87***g* of the exterior plate **85**, **87** meets one of the first exterior plates side **85***b*, **87***b* and the second exterior plate side **85***b*, **87***b*.

In addition and as illustrated in FIG. **5***a*, the embodiment of the second connector **80** also optionally includes at least one interior plate **86** disposed between and coupled to the interior extension **81** and the another interior extension **82**. The interior plate **86** includes an interior plate base **86***a* aligned substantially in a plane with each of the second bases **81***a*, **82***a* of the interior extensions **81**, **82** and the exterior plate bases **85***a*, **87***a*. In addition, a first interior plate side **86***b* of the interior plate **86** is positioned adjacent to the second side **81***c*, **82***c* of one of the interior extensions **81**, **82**, and a second interior plate side **86***c* of the interior plate **86** is positioned adjacent to the first side **81***b*, **82***b* of the other interior extension **81**, **82**.

In some embodiments, the first connector **70** optionally includes a plurality of welds **100** (FIG. **6**) that couple the interior plate or plates of the connector **70** to one or more of the extensions. Likewise, the connector **80** optionally includes a plurality of welds **101** that couple the interior plate or plates of the connector **80** to one or more of the extensions. For example and as illustrated in FIGS. **4***a* and **6**, connector **70** includes a plurality of welds **100** that couple the interior plates **74** and **75** to one or more of the extensions **71**, **72**, and **73**. As illustrated, a weld(s) **100** optionally follow a periphery **74***i* to couple the interior plate **74** to at least to the exterior extension **73** and, optionally, to the interior extension **72**. A weld(s) **100** optionally follow a periphery **75***i* to couple the interior plate **75** to at least to the interior extension **72** and, optionally, to the exterior extension **71**. Similarly and as illustrated in FIGS. **5***a* and **8**, connector **80** includes a plurality of welds **101** that couple the exterior plates **85**, **87** to one or more of the interior extensions **81**, **82**, and, optionally, the interior plate **86** to one or more of the interior extensions **81**, **82**. As illustrated, a weld(s) **101** optionally follow a periphery **85***i* to couple the exterior plate **85** to at least the interior extension **81**, and a weld(s) **101** optionally follow a periphery **87***i* to couple the exterior plate **87** to at least the interior extension **82**.

Optionally, and as previously noted, at least a part of the first connector mounting surface **78** is welded to the first column or boom segment **53**. Likewise, at least a part of the second connector mounting surface **88** optionally is welded to the second column or boom segment **54**. Just as the first connector mounting surface **78** may include at least one hole **79** (FIG. **6**) to assist in aligning and coupling the first connector mounting surface **78** to the first column or boom segment **53**, the second connector mounting surface **88** may include a similar hole **89** (FIG. **8**) to assist in aligning and coupling the second connector mounting surface **88** to the second column or boom segment **54**. While the holes **79**, **89** are illustrated in the second base **72***a* and the plate base **86***a*, respectively, it will be understood that the hole **79** and the hole **89** can be located at any desired location in the first connector mounting surface **78** and the second connector mounting surface **88**, respectively.

As previously noted, at least one of the exterior extensions **71**, **73** and the interior extension **72** is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to at least one of the first base **71***a*, **71***a*, **73***a*. Similarly, at least one of the interior extensions **81**, **82** of the second connector **80** optionally is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to at least one of the second base **81***a*, **82***a*, respectively.

Referring now to FIGS. **11-13**, another embodiment of a column or boom connector system **210** is disclosed in which the connector system **210** includes a first column or boom segment **253** having a first end **257***a* and a second end **257***b* and at least a second column or boom segment **254** also having a first end **259***a* and a second end **259***b*, as illustrated in FIG. **11**.

In FIG. **12**, a first connector **270** on the second end **257***b* of the first column or boom segment **253** includes at least two exterior extensions **271**, **273**, with each exterior extension **271**, **273** having a first base **271***a*, **273***a*, a first side **271***b*, **271***b* perpendicular to the first base **271***a*, **273***a*, and a second side **271***c*, **273***c* spaced apart from the first side **271***b*, **273***b* and also perpendicular to the first base **271***a*, **273***a*. A first aperture **271***d*, **273***d* extends through each of the exterior extensions **271***b*, **273**. In this embodiment, n equals 2. In addition, the exterior extensions **271**, **273** optionally include all of the various features and elements ascribed to exterior extensions **71**, **73** described above and illustrated in FIGS. **4***a*, **6**, and **7**.

The first connector **270** also includes at least one interior plate **274** coupled to at least one of the exterior extensions **271**, **273**. Here, (n+y) equals 1 plate as y equals −1. The interior plate **274** includes an interior plate base **274***a* aligned substantially in a plane with the first base **271***a*, **273***a* to form a first connector mounting surface, similar to the first connector mounting surface **78** illustrated in FIGS. **6** and **7**. A first interior plate side **274***b* is perpendicular to the interior plate base **274***a* and positioned adjacent to one of the first side **271***b*, **273***b* and the second side **271***c*, **273***c* of one of the exterior extensions **271**, **273**. A second interior plate side **274***c* also is perpendicular to the interior plate base **274***a* and is spaced apart from the first interior plate side **274***b*. The second interior plate side **274***c* is positioned adjacent to the other of the first side **271***b*, **273***b* and the second side **271***c*, **273***c* of the other exterior extension **271**, **273** of the first connector **270**. The interior plate **274** optionally includes all of the various features and elements ascribed to interior plate **74** described above and illustrated in FIGS. **4***a*, **6**, and **7**.

The column or boom connector system **210** also includes a second connector **280** on the first end **259***a* of the second column or boom segment **254**, as seen in FIG. **11**. The second connector **280** includes at least one interior extension **281** having a second base **281***a*, a first side **281***b* perpendicular to the second base **281***a*, a second side **281***c* also perpendicular to the second base **281***a* and spaced apart from the first side **281***b*, and a second aperture **281***d* through the interior extension **281**, as illustrated in FIG. **13**. In addition, the interior extension **281** optionally includes all of the various features and elements ascribed to interior extension **81** described above and illustrated in FIGS. **5***a*, **8**, and **9**.

The second connector **280** also includes a first exterior plate **285** and a second exterior plate **287** (n equals 2 in the embodiments illustrated in FIGS. **11-13**, as noted above), at least one of the first exterior plate **285** and the second exterior plate **287** being coupled to the at least one interior extension **281**. Each of the first exterior plate **285** and the second exterior plate **287** has an exterior plate base **285***a*, **287***a* aligned substantially in a plane with the second base **281***a* of the at least one interior extension **281** to form a second connecting mounting surface, similar to the first connector mounting surface **88** illustrated in FIGS. **8** and **9**.

Each exterior plate **285**, **287** also includes a first exterior plate side **285***b*, **287***b* perpendicular to the exterior base plate **285***a*, **287***a* and a second exterior plate side **285***c*, **287***c* also perpendicular to the exterior base plate **285***a*, **287***a* and spaced apart from the first exterior plate side **285***b*, **287***b*. The second exterior plate side **285***c* of the first exterior plate **285** is positioned adjacent the first side **281***b* of the at least one interior extension **281** of the second connector **280** and the first exterior plate side **287***b* of the second exterior plate **287** is positioned adjacent the second side **281***c* of the at least one interior extension **281** of the second connector **280**. The exterior plates **285**, **287** optionally include all of the various features and elements ascribed to exterior plates **85**, **87** described above and illustrated in FIGS. **5***a*, **8**, and **9**.

A pin (not illustrated), similar to pin **90** illustrated in FIG. **10**, is inserted through the first aperture **271***d*, **273***d* of each exterior extension **271**, **273** and the second aperture **281***d* of each interior extension **281** of the first connector **270** and the second connector **280**, respectively, and couples the first connector **270** to the second connector **280**.

The present invention, in various embodiments, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments hereof, including in the absence of such items as may have been used in previous devices or processes, e.g., for improving performance, achieving ease and/or reducing cost of implementation.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the invention are grouped together in one or more embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations and modifications are within the scope of the invention, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

The invention claimed is:

1. A column segment of a column of a crane, the column having multiple segments coupled together with a column connector system, the crane having an upper works rotatably mounted on a lower works, the upper works including a load hoist winch, the column segment comprising:

a) a plurality of chords in which a lattice structure couples each chord to at least another chord, each chord having a first end and a second end;

b) a first connector on the second end of at least one of the chords, the first connector including:

n extensions, where n is a positive integer, each extension having:

a first base;

a first side extending away from the first base;

a second side extending away from the first base, the second side being spaced apart from the first side; and;

a first aperture extending through the extension from the first side to the second side;

wherein at least one extension is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to the first base;

at least (n+y) plates, where y is selected from the group consisting of (−1, +1) such that the sum of (n+y) is a positive integer, the plates positioned in and coupled to the extensions in an alternating arrangement, the plates having:

a plate base aligned substantially in a plane with the first base to form a first connector mounting surface;

a first plate side extending away from the plate base, the first plate side being positioned adjacent to one of the first side and the second side of one of the extensions; and,

a second plate side extending away from the plate base, the second plate side being spaced apart from the first plate side.

2. The column segment of claim **1**, wherein the extensions comprise at least one interior extension when n is an odd integer greater than or equal to 1, the interior extension having a first distance between the first side and the second side, and at least two exterior extensions when n is an integer greater than or equal to 2, the exterior extensions each having a second distance between the first side and the second side that is less than the first distance.

3. The column segment of claim **1**, wherein the column segment further comprises a plurality of welds that couple the plates to the extensions.

4. The column segment of claim **1**, wherein at least a part of the first connector mounting surface is welded to the first column segment.

5. The column segment of claim **1**, wherein the first connector mounting surface includes at least one hole configured to align the first connector to the first column segment.

6. The column segment of claim **1**, wherein at least one of the plates further comprises:

a plate surface spaced laterally apart from the plate base;

a plate top extending away from the plate base, the plate top intersecting the first plate side and the second plate side;

a plate bottom extending away from the plate base, the plate bottom intersecting the first plate side and the second plate side, the plate bottom being spaced apart from the plate top;

a first surface that extends away from the plate base, the plate surface, the plate top, and the plate bottom until the first surface meets the first plate side; and,

a second surface that extends away from the plate base, the plate surface, the plate top, and the plate bottom until the second surface meets the second plate side.

7. A combination of the column segment of claim **1** coupled to another column segment, the another column segment comprising:

a) another plurality of chords in which another lattice structure couples each chord of the another plurality to at least another chord of the another plurality, each chord of the another plurality having a first end and a second end;

b) a second connector on the first end of at least one of the chords of the another plurality, the second connector including:

(n+y) extensions, each extension having:

a second base;

a first side extending away from the second base;

a second side extending away from the second base, the second side being spaced apart from the first side; and;

a second aperture extending through the extension from the first side to the second side;

at least n plates, the plates positioned in and coupled to the extensions in an alternating arrangement, the plates having:

a plate base aligned substantially in a plane with the second base to form a second connector mounting surface;

a first plate side extending away from the plate base, the first plate side being positioned adjacent to one of the first side and the second side of one of the extensions of the second connector; and,

a second plate side extending away from the plate base, the second plate side being spaced apart from the first plate side; and,

c) a pin inserted through the first aperture of each extension of the first connector and the second aperture of each extension of the second connector, the pin coupling the first connector to the second connector.

8. The combination of claim **7**, wherein the second connector is cast as a unitary structure.

9. A column connector system for a crane having a column with multiple segments coupled together with the column connector system, the crane having an upper works rotatably mounted on a lower works, the upper works including a load hoist winch, the column connector system comprising:

a) a first column segment having a first end and a second end;

b) at least a second column segment having a first end and a second end;

c) a first connector on the second end of the first column segment, the first connector including:

at least two exterior extensions, each exterior extension having:

a first base;

a first side perpendicular to the first base;

a second side perpendicular to the first base, the second side being spaced apart from the first side; and,

a first aperture through the exterior extension;

at least one interior plate coupled to at least one of the exterior extensions, the interior plate having:

an interior plate base aligned substantially in a plane with the first base to form a first connector mounting surface;

a first interior plate side perpendicular to the interior plate base, the first interior plate side being positioned adjacent to one of the first side and the second side of one of the exterior extensions; and,

a second interior plate side perpendicular to the interior plate base, the second interior plate side being spaced apart from the first interior plate side;

d) a second connector on the first end of the second column segment, the second connector including:

at least one interior extension having:

a second base;

a first side perpendicular to the second base;

a second side perpendicular to the second base, the second side being spaced apart from the first side; and,

a second aperture through the interior extension

a first exterior plate and a second exterior plate, at least one of the first exterior plate and the second exterior plate being coupled to the at least one interior extension, each of the exterior plates having:

an exterior plate base aligned substantially in a plane with the second base of the at least one interior extension of the second connector to form a second connector mounting surface;

a first exterior plate side perpendicular to the exterior plate base;

a second exterior plate side perpendicular to the exterior plate base, the second exterior plate side being spaced apart from the first exterior plate side;

e) a pin inserted through the first aperture of each exterior extension and the second aperture of each interior extension of the first connector and the second connector, the pin coupling the first connector to the second connector; and,

f) wherein at least one of the exterior extensions and the interior extension is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to at least one of the first base and the second base, respectively.

10. The column connector system of claim **9**, wherein the second interior plate side of the first connector is positioned adjacent to the other of the first side and the second side of the other exterior extension of the first connector and wherein the second exterior plate side of the first exterior plate is positioned adjacent the first side of the at least one interior extension of the second connector and the first exterior plate side of the second exterior plate is positioned adjacent the second side of the at least one interior extension of the second connector.

11. The column connector system of claim **9**, wherein the first connector further comprises:

at least one interior extension, wherein the interior plate of the first connector is disposed between and coupled to the interior extension and at least one exterior extension, the second interior plate side being positioned adjacent to one of the first side and the second side of the interior extension, the interior plate base being aligned substantially in a plane with the second base of the interior extension of the first connector;

another interior plate disposed between and coupled to the interior extension and the other exterior extension, the another interior plate having:

another interior plate base aligned substantially in a plane with the first base of the first extensions and the second base of the interior extension;

another first interior plate side perpendicular to the another interior plate base, the another first interior plate side being positioned adjacent to the other of the first side and the second side of the exterior extension; and,

another second interior plate side perpendicular to the interior plate base, the another second interior plate side being spaced apart from the another first interior plate side, the another second interior plate side being positioned adjacent to the other of the first side and the second side of the interior extension; and,

wherein the second connector further comprises:

another interior extension;

at least one interior plate disposed between and coupled to the interior extension and the another interior extension of the second connector, the interior plate base being aligned in a plane with each of the second bases of the interior extensions and the exterior plate bases of the second connector, the first interior plate side being positioned adjacent to the second side of one of the interior extensions, and the second interior plate side of the second connector being positioned adjacent to the first side of the other interior extension.

12. The column connector system of claim **9**, wherein the first connector further comprises a plurality of welds that couple the interior plate to at least one of the exterior extensions and wherein the second connector further comprises a plurality of welds that couple at least one of the exterior plates to the interior extension.

13. The column connector system of claim **9**, wherein the interior plate further comprises:

an interior plate surface spaced laterally apart from the interior plate base;

an interior plate top extending away from the interior plate base, the interior plate top intersecting the first interior plate side and the second interior plate side;

an interior plate bottom extending away from the interior plate base, the interior plate bottom intersecting the first interior plate side and the second interior plate side, the interior plate bottom being spaced apart from the interior plate top;

a first surface that extends away from the interior plate base, the interior plate surface, the interior plate top, and the interior plate bottom until the first surface meets the first interior plate side; and,

a second surface that extends away from the interior plate base, the interior plate surface, the interior plate top, and the interior plate bottom until the second surface meets the second interior plate side; and,

wherein each exterior plate includes:

an exterior plate surface spaced laterally apart from the exterior plate base;

an exterior plate top extending away from the exterior plate base, the exterior plate top intersecting the first exterior plate side and the second exterior plate side;

an exterior plate bottom extending away from the exterior plate base, the exterior plate bottom intersecting the first exterior plate side and the second exterior plate side, the exterior plate bottom being spaced apart from the exterior plate top; and,

a first surface that extends away from the exterior plate base, the exterior plate surface, the exterior plate top, and the exterior plate bottom until the first surface of the exterior plate meets one of the first exterior plate side and the second exterior plate side.

14. The column connector system of claim **9**, wherein at least a part of the first connector mounting surface is welded to the first column segment and at least a part of the second connector mounting surface is welded to the second column segment.

15. The column connector system of claim **9**, wherein at least one of the first connector mounting surface and the second connector mounting surface includes at least one hole configured to align at least one of the first connector to the first column segment and the second connector to the second column segment.

16. A boom connector system for a crane having a boom with multiple segments coupled together with the boom connector system, the crane having an upper works rotatably mounted on a lower works, the upper works including a load hoist winch, the boom connector system comprising:

a) a first boom segment having a first end and a second end;

b) at least a second boom segment having a first end and a second end;

c) a first connector on the second end of the first boom segment, the first connector including:

two exterior extensions, each exterior extension having:

a first base;

a first side perpendicular to the first base;

a second side perpendicular to the first base, the second side being spaced apart from the first side; and,

a first aperture through the exterior extension;

at least one interior extension having:

a second base;

a first side perpendicular to the second base;

a second side perpendicular to the second base, the second side being spaced apart from the first side; and,

a second aperture through the interior extension;

an interior plate disposed between and coupled to the interior extension and one of the exterior extensions, another interior plate disposed between and coupled to the interior extension and the other exterior extension, each of the interior plates having:

an interior plate base aligned substantially in a plane with the first base and the second base to form a first connector mounting surface;

a first interior plate side perpendicular to the interior plate base, the first interior plate side being positioned adjacent to the second side of the exterior extension; and,

a second interior plate side perpendicular to the interior plate base, the second interior plate side being spaced apart from the first interior plate side, the second interior plate side being positioned adjacent to one of the first side and the second side of the interior extension;

d) a second connector on the first end of the second boom segment, the second connector including:

at least two interior extensions;

at least one interior plate disposed between and coupled to each of the two interior extensions of the second connector, the interior plate base being aligned in a plane with each of the first bases of the two interior extension of the second connector to form a second connector mounting surface, the first interior plate side being positioned adjacent to the second side of one of the interior extensions of the second connector, and the second interior plate side being positioned adjacent to the first side of the other interior extension of the second connector;

an exterior plate coupled to one of the interior extensions, another exterior plate coupled to the other interior extension, each of the exterior plates having:

an exterior plate base aligned substantially in a plane with the second base of each of the interior extensions of the second connector to form a second connector mounting surface;

a first exterior plate side perpendicular to the exterior plate base; and,

a second exterior plate side perpendicular to the exterior plate base, the second exterior plate side being spaced apart from the first exterior plate side, the second exterior plate side being positioned adjacent to one of the first side and the second side of one of the interior extensions of the second connector;

e) a pin inserted through the first aperture of each exterior extension and the second aperture of each interior extension of the first connector and the second connector, the pin coupling the first connector to the second connector; and,

f) wherein at least one of the exterior extensions and the interior extensions is formed of steel having a grain structure elongated in a direction of rolling that is substantially perpendicular to at least one of the first base and the second base, respectively.

17. The boom connector system of claim **16**, wherein the first connector further comprises a plurality of welds that couple each of the interior plates to the interior extension and the respective exterior extensions and wherein the second connector further comprises a plurality of welds that couple each of the of the exterior plates to the respective interior extension and the interior extension to the interior plate.

18. The boom connector system of claim **16**, wherein each interior plate further comprises:

an interior plate surface spaced laterally apart from the interior plate base;

an interior plate top extending away from the interior plate base, the interior plate top intersecting the first interior plate side and the second interior plate side;

an interior plate bottom extending away from the interior plate base, the interior plate bottom intersecting the first interior plate side and the second interior plate side, the interior plate bottom being spaced apart from the interior plate top;

a first surface that extends away from the interior plate base, the interior plate surface, the interior plate top, and the interior plate bottom until the first surface meets the first interior plate side; and,

a second surface that extends away from the interior plate base, the interior plate surface, the interior plate top, and the interior plate bottom until the second surface meets the second interior plate side; and,

wherein each exterior plate includes:

an exterior plate surface spaced laterally apart from the exterior plate base;

an exterior plate top extending away from the exterior plate base, the exterior plate top intersecting the first exterior plate side and the second exterior plate side;

an exterior plate bottom extending away from the exterior plate base, the exterior plate bottom intersecting the first exterior plate side and the second exterior plate side, the exterior plate bottom being spaced apart from the exterior plate top; and,

a first surface that extends away from the exterior plate base, the exterior plate surface, the exterior plate top, and the exterior plate bottom until the first surface of the exterior plate meets the second exterior plate side.

19. The boom connector system of claim **16**, wherein at least a part of the first connector mounting surface is welded to the first boom segment and at least a part of the second connector mounting surface is welded to the second boom segment.

20. The boom connector system of claim **16**, wherein at least one of the first connector mounting surface and the second connector mounting surface includes at least one hole configured to align at least one of the first connector to the first boom segment and the second connector to the second boom segment.

* * * * *